

Influence of Internal Fixation and Cemented Hemiarthroplasty on 1-Year Mortality in Geriatric Hip Fracture Patients

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ABSTRACT

AIM: Results after cemented Hemiarthroplasty (HA) in elderly patients with a femoral neck fracture improved over the last 20 years. We conducted this study in order to evaluate the influence of modern cemented HA compared to IF with a sliding hip screw (SHS) with regard to one year mortality.

PATIENTS AND METHODS: 183 patients with a low-energy medial femoral neck fracture (AO/OTA 31-B) either treated with a SHS ($n = 67$) or cemented HA ($n = 116$) were included. Follow-up was performed at 6 and 12 months. A multivariate Cox regression

analysis including nine confounding variables (age, ASA score, body mass index (BMI), cognitive function, time from admission to surgery, creatinine, c-reactive protein (CRP), 25-hydroxyvitamin D (25(OH)D) was performed.

RESULTS: Patients in the HA group were significantly older ($p < 0.001$) and had more severe comorbidities according to the ASA-Score ($p = 0.017$). The time interval from admission to surgery (skin incision) was beyond 48h in 6.0% of SHS patients and 17.2% in HA patients ($p < 0.001$). Despite of detrimental prerequisites for cemented HA, mortality rates at 1 year for HA (23.3%) showed no significant difference ($p = 0.58$) to IF (19.4%). After correcting for confounding variables mortality risk at one year was significantly higher in patients treated with a SHS (HR = 2.5, 95%CI 1.1-5.7; $p = 0.027$).

CONCLUSION: We conclude that elderly patients with a femoral neck fracture might benefit from cemented HA compared to IF with a SHS in terms of 1-year mortality. New randomised controlled trials considering modern cementing techniques are needed to validate these results.

Key words: Femoral neck fracture; Hip fracture; Internal fixation; Sliding hip screw; Hemiarthroplasty; Mortality

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INTRODUCTION

Femoral neck fractures in elderly patients are associated with high mortality particularly during the first year. This leads to an excess mortality of 8-18% in elderly hip fractures patients after one year compared to matched controls without a hip fracture^[1]. The overall 1-year mortality rates after hip fracture is reported to be as high as 36%^[2]. Many risk factors, such as age, comorbidities, cognitive

impairment or level of activity were shown to be associated with an increased mortality risk in these patients^[3,4]. Moreover, several laboratory parameters such as haemoglobin, albumin, creatinine, c-reactive protein (CRP) and 25-hydroxyvitamin D (25(OH)D) were found to be associated with an increased mortality after hip fracture^[5-7]. In contrary, the influence of the surgical management in this regard seems to be of minor importance. Numerous randomized controlled trails (RCTs) and meta-analyses demonstrated no difference in one year mortality between internal fixation (IF) and hemiarthroplasty (HA)^[8-12]. But many of these studies restrict their inclusion criteria to only a subset of patients which might result in considerable bias. For instance, several RCTs exclude patients with cognitive impairment^[10,11] which on the other side comprise up to 30% of elderly patients with hip fracture^[8,13]. Cognitive impairment was identified as a risk factor for mortality in these patients^[4,13]. Furthermore, potentially important confounders as timing of surgery are not respected in recent RCTs^[8-11], although it was shown that a delay in surgery is associated with increased morbidity^[14] and mortality^[15].

Beyond study design, the time period of patient recruitment should be considered which in most of the studies comparing IF with cemented HA date back almost 10 years or even longer^[8-11,16-18]. This is of importance, since Schnependahl and colleagues^[19] reported a decreasing mortality after femoral neck fractures treated with bipolar HA over the last twenty years with the most pronounced effect seen after 2006. Subsequently, a potentially beneficial effect of cemented bipolar HA on mortality compared to IF within recent years cannot be precluded. Moreover, it is well proofed that HA is superior to IF in terms of hip pain and function after 1 year^[12] subsequently providing better mobility and activity which in turn may also affect morbidity and mortality.

In this prospective observational study, we analysed one year mortality in elderly patients that sustained a femoral neck fracture and were treated with IF or cemented bipolar HA after 2010. Considering potential confounding variables we hypothesized that cemented bipolar HA is associated with decreased mortality compared to IF.

PATIENTS AND METHODS

From January 2011 to March 2014 183 patients with a medial femoral neck fracture (AO/OTA 31-B) were included in the present single centre, prospective cohort study. Inclusion criteria were an age of 50 years or older and a low-energy trauma. Female patients represented 80% (*n* = 146) and male patients 20% (*n* = 37) of the study population. Patients with a high-energy trauma, i.e. fall from height or traffic accidents were excluded as well as patients with a pathological fracture or death prior to surgery. All included patients or their legal representative gave written informed consent.

Apart from patient age, the body mass index (BMI) and medication was recorded (Table 1). Comorbidities were graded according to the American Society of Anaesthesiologists (ASA) score^[20]. Additionally, the ambulatory status and pain in the hip prior to fracture was assessed referring to the Merle d'Aubigné score^[21]. A cognitive impairment was assumed in patients with an existing diagnosis of any form of dementia at admission or in patients that were legally not competent to sign documents. In hospital medical complications after surgery warranting intervention were documented. Moreover, surgical complications that required another surgery were recorded.

6 and 12 months after surgery patients or their authorized representative and, if necessary, their general practitioner, were contacted by phone and asked about walking ability and pain in the

Table 1 Baseline characteristics of patients treated with IF (SHS) and hemiarthroplasty

	SHS (<i>n</i> = 67)	Hemiarthroplasty (<i>n</i> = 116)	<i>p</i>
Age	75 (66-84)	84 (77-89)	< 0.001*
Women	70%	85%	0.021*
BMI (mean)	25 (21-28)	25 (23-28)	0.667
ASA Score			0.017*
I	4.5%	0%	
II	34.3%	22.4%	
III	59.7%	76.7%	
IV	1.5%	0.9%	
Cognitive impairment	20.9%	34.5%	0.064
Medication			
oral anticoagulant	1.50%	10.50%	0.033*
antiplatelet therapy	37.90%	28.10%	0.187
Living in nursery home	25.4%	33.6%	0.251
Merle'd Aubigne functional Score	12.0 (7.0-12.0)	9.0 (7.0-12.0)	0.033*
25 (OH)D (ng/mL)	10.8 (7.0-18.8)	7.8 (5.8-13.0)	0.002*
CRP (mg/L)	5.2 (1.3-21.1)	4.8 (1.6-15.4)	0.896
creatinine (μmol/L) (mean)	66 (55-81)	75 (65-97)	0.009*
hemoglobin (mmol/L)	7.9 (7.3-8.7)	8.0 (7.2-8.6)	0.579
total leucocyte count (exp 9/L)	10.3 (7.8-13.7)	10.9 (8.1-13.4)	0.858
platelets (exp 9/L)	224 (193-260)	231 (193-275)	0.333
prothrombine time (PT; %)	98 (90-109)	101 (89-110)	0.851

Continuous values are given as median (IQR) or as percentage. * *p* < 0.05.

Table 2 Perioperative results.

	SHS (<i>n</i> = 67)	Hemiarthroplasty (<i>n</i> = 116)	<i>p</i>
Time from admission to surgery (skin incision) in hours	15 (11-29)	31 (22-44)	<0.001*
Time from admission to surgery (skin incision) > 48 h	6.0%	17.2%	<0.001*
duration of surgery (minutes)	53 (42-65)	67.0 (53-85)	<0.001*
surgery performed by resident	79%	12%	<0.001*
Garden classification III or IV	29.9%	89.6%	<0.001*
medical complication	10.4%	22.4%	0.047*
cardiovascular	1.5%	6.9%	
thromboembolic	1.5%	0.9%	
infection (except wound)	4.4%	7.8%	
other (confusion, ...)	3.0%	6.9%	
surgical complications (in-hospital)	4.5%	9.5%	0.262
implant failure at 1 year	22.7%	7.9%	0.005*
mortality			
30 day	11.9%	12.9%	0.999
1 year	19.4%	23.3%	0.580

Continuous values are given as median (IQR) or as percentage. * *p* < 0.05.

concerned hip according to the Merle d'Aubigné score. Furthermore, complications related to the surgery were documented. Implant failure was defined as partial or total removal or replacement of the original implant. Except those who deceased, no patient was lost during follow-up at 12 months. Two patients (1.1%) refused to answer the questions of the protocol at one year, but were still alive at that time. Mortality rates were calculated at 30 days and 1 year.

All surgeries were performed in general anesthesia. Internal fixation was performed with a sliding hip screw (SHS; DePuy-

Synthes West Chester, USA) after closed reduction on an extension-table. Bipolar endoprotheses (DePuy, Warsaw, USA) were implanted using the Hardinge approach. After preparation of the medullary canal a plug was inserted and pulsatile jet-lavage was applied before cementing and implanting the stem. Decision on whether to use SHS or HA was mainly based on the degree of fracture dislocation. Non-displaced fractures (Garden I and II) were usually treated with a SHS, whereas HA was used for displaced fractures (Garden III and IV). Patients younger than 60 years more likely were treated with a SHS. Furthermore, training of the surgeon and patient profiles influenced the decision making. Qualification of the surgeons, time from admission to begin of surgery (skin incision) and duration of the surgery was recorded (Table 2).

Blood samples for routine laboratory parameters in particular creatinine, CRP, hemoglobin and total leukocyte count were drawn immediately after admission to the emergency room. Serum 25(OH) D was determined with the LIAISON® 25-OH Vitamin D assay (DiaSorin, Stillwater, MN, USA).

All values are given as median and the interquartile range (IQR) [25th–75th percentile]. The following statistical tests were applied: chi-square-test, Mann-Whitney-U-Test, Kaplan-Meier survival analysis, log rank (Mantel-Cox), Spearman correlation, uni- and multivariate Cox regression analysis. Confounding variables included in the multivariate Cox regression analysis were age, sex, ASA score, body mass index (BMI), cognitive function, time from admission to surgery, creatinine, CRP, 25(OH)D. All statistical computations were performed using SPSS version 20.0 (Chicago, IL, USA). P values less than 5% were considered as significant.

RESULTS

The 30-day mortality of patients receiving an IF was 11.9% compared to 12.9% after HA ($p = 0.999$). Similarly, no difference of mortality rates at one year were observed with 19.4% after IF and 23.3% after cemented HA ($p = 0.580$). However, patient demographics and baseline characteristics demonstrated significant differences (Table 1). Patients in HA group were significantly older ($p < 0.001$) and had more severe comorbidities demonstrated by higher ASA-Scores ($p = 0.017$). Furthermore, the preoperative Merle'd Aubigne functional score consisting of hip pain and walking capacity was significantly worse in patients receiving cemented HA ($p = 0.033$). Routine laboratory parameters were comparable in both groups (Table 1). But 25(OH) D was considerably lower in patients allocated to HA ($p = 0.002$). The time interval from admission to surgery (skin incision) was beyond 48h in 6.0% of IF patients and 17.2% in HA patients ($p < 0.001$) (Table 2).

Despite of the heterogeneity of both groups in favour of patients receiving an IF, mortality rates at one year represented no significant differences. A multivariate Cox-regression analysis was performed in order to correct for potential confounding factors affecting mortality (Figure 1). After including patient characteristic variables, biochemical parameters, time from admission to surgery and the type of implant, mortality risk at one year was significantly higher in patients treated with IF (HR = 2.5, 95% CI 1.1-5.7; $p = 0.027$) (Table 3). In opposition, risk of death at 30 days showed no difference between implants (HR = 2.5, 95% CI 0.8-7.2; $p = 0.103$). Residents performed 79% of surgeries with IF, attending surgeons 21%. In contrary, HA was performed in 88% of patients by attending surgeons and 12% by residents. No significant association between qualification of surgeon and 1-year mortality was observed ($p = 0.583$) (Table 2).

Table 3 Multivariate Cox regression analysis of potential confounders associated with 1-year mortality.

	Hazard Ratio (95% CI)	p
age	1.080 (1.030-1.132)	< 0.001*
sex	1.889 (0.5763-6.221)	0.296
BMI	1.031 (0.968-1.099)	0.342
ASA score	2.023(0.748-5.575)	0.165
Cognitive Impairment	2.023 (0.560-2.370)	0.702
time interval admission to surgery	1.012 (1.001-1.022)	0.027*
serum 25(OH)D	0.960 (0.898-1.027)	0.237
serum creatinine	1.006 (0.997-1.016)	0.203
serum CRP	1.010 (1.004-1.016)	<0.001*
implant (HA, SHS)	2.527 (1.112-5.742)	0.027*

* $p < 0.05$.

Table 4 Functional score comparing SHS and Hemiarthroplasty at baseline and 12 months postoperatively.

	SHS	Hemiarthroplasty	p
Merle d'Aubigné Score 0 Mon.	67	116	
Pain	6.0 (6.0-6.0)	6.0 (6.0-6.0)	0.031*
Walking ability	6.0 (1.0-6.0)	3.0 (1.0-6.0)	0.077
Functional Score	12.0 (7.0-12.0)	9.0 (7.0-12.0)	0.033*
Merle d'Aubigné Score 12 Mon.			
Pain	6.0 (4.0-6.0)	6.0 (5.0-6.0)	0.071
Walking ability	2.0 (1.0-5.0)	1.0 (1.0-2.0)	0.032*
Functional Score	7.0 (6.0-9.5)	7.0 (6.0-8.0)	0.392

Continuous values are given as median (IQR). * $p < 0.05$.

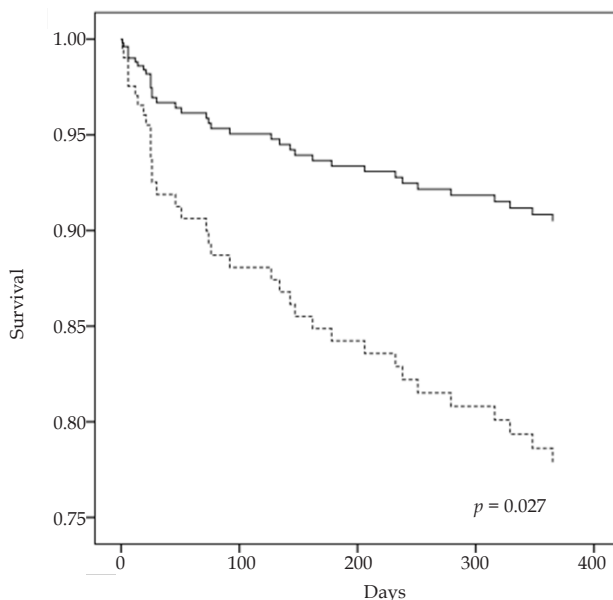


Figure 1 1-year survival analysis comparing internal fixation and hemiarthroplasty Multivariate Cox regression analysis of 1-year survival comparing cemented hemiarthroplasty (continuous line) and internal fixation with a SHS (dotted line). Included co-variables: age, sex, BMI, ASA classification, cognitive function, time interval admission to surgery, creatinine, CRP, 25(OH)D.

The postoperative rate of in-hospital surgical complications was twice as high after HA compared to IF, but did not reach significance ($p = 0.262$). In contrary, in-hospital medical complications were significantly higher in the HA group ($p = 0.047$). Within one year

implant failure was higher after osteosynthesis ($p = 0.005$) which warranted conversion from IF to HA or total hip arthroplasty (THA) in 22.7%. The Merle'd Aubigne functional score at baseline was significantly better in patients receiving IF ($p = 0.033$), but approximated after 12 months ($p = 0.392$). In the IF group the functional score fell from a median of 12 to 7, in the HA group from a median of 9 to 7. Subsequently, functional loss was more pronounced after IF, although the delta was not significantly ($p = 0.565$) (Table 4).

DISCUSSION

Without considering confounding variables 1-year mortality in our study cohort of elderly patients with a medial femoral neck fracture seems not be influenced by the surgical procedure or choice of implant. However, patients in the HA group were significantly older, had more severe comorbidities reflected by ASA-Scores and presented with cognitive impairment more frequently. These factors are associated with a higher mortality after hip fracture^[4]. Moreover, some laboratory parameters differed considerably between groups. Higher mortality rates after hip fracture were identified in patients with low hemoglobin, high leucocyte count, creatinine levels^[6] or high CRP^[7]. A potential effect of 25(OH)D levels on mortality is discussed controversially^[22,23]. In hip fracture patients Madsen *et al*^[24] found no association between 25(OH)D levels and 1-year mortality. Others identified severe vitamin D deficiency as a significant predictor of 1-year mortality after femoral neck fracture in elderly patients. However, an independent association was not shown, potentially due to a limited number of patients^[7]. A delay in surgery of hip fracture patients might be an indicator for the need of more intense preoperative diagnostic work-up and conditioning of patients with acute illness or deterioration of chronic disease. In our study a significantly longer time from admission to surgery was recorded in the HA group corresponding to higher ASA-Scores. An association of delay in surgery and higher mortality rates after one year has been reported earlier^[15,25]. Consequently, we also considered the time interval from admission to surgery as a confounding variable.

Results of our multivariate Cox-regression analysis are in contrast to the vast majority of trials^[8-11,16-18,26]. Several studies reported higher one year mortality rates for HA than IF^[18,26,27]. Heetveld *et al*^[18] stratified significantly younger, healthier and more mobile patients to IF resulting in a 1-year mortality of 9% compared to 32% in all other patients receiving HA. Consequently, direct comparison of mortality rates which in fact was not the primary aim of this study prohibits a valid interpretation. Nevertheless, this study was included in a recent meta-analysis comparing arthroplasty with IF^[12] which may distort results in terms of mortality. A recent matched-control observational study^[27] with 13.772 patients in each arm revealed a significantly higher cumulative mortality for displaced medial femoral neck fractures treated with HA compared to undisplaced fractures receiving IF. At 12 months mortality rates were 14.5% and 13.4%, respectively^[27]. However, stratifying treatment to severity of hip fractures may be associated with considerable bias, since a higher degree of fracture displacement is significantly associated with hypovitaminosis D^[28] which in turn may affect morbidity and mortality in these patients^[7]. Only one retrospective study found a higher cumulative mortality after internal fixation compared to HA^[29]. But this was only documented for patients aged 65 to 80 years with appreciable mortality differences becoming apparent only at 18 months^[29].

RCTs are the gold standard in assessing the suitability of surgical implants for femoral neck fractures^[30] and consequently evidence

of results is superior to our study design. However, RCTs are also associated with limitations^[30]. Selection of patients by predefined exclusion criteria may result in a bias. Davison *et al*^[26] included only patients with an age between 65 and 79 years. Keating *et al*^[9] excluded patients with serious concomitant disease, unnormal cognitive function as well as patients needing support with walking. This disregards a major percentage of geriatric trauma patients. Moreover, cognitive impairment which was demonstrated to be a risk factor for higher mortality in hip fracture patients^[4,31] was ignored. Similarly, other RCTs^[10,11,32] and non-randomised studies did not respect patients who were confused or had neurologic impairment^[17,18] as well as patients incapable of independent walking or who were bed-ridden^[9,10]. Subsequently, at least one third of hip fracture patients are disobeyed according to our study cohort. This is confirmed by Frihagen *et al*^[8] who also identified approximately one third of femoral neck fracture patients suffering from cognitive impairment. Another factor potentially influencing mortality which is time to surgery or patients referred to surgery beyond 48 h are not addressed in all recent randomised and non-randomised trials^[8-11,16-18,32-34]. In our study timing of surgery was associated with significantly higher one year mortality. In accordance with our data Frihagen *et al*^[8] also detected a significantly higher delay until surgery in the hemiarthroplasty group, but this was not considered as a potential confounder with regard to 1-year mortality. However, the association of surgical timing on mortality is discussed controversially^[14,15,25,35].

Apart from study design, the historical time period of patient recruitment might influence mortality since Schnependahl and colleagues have shown that the mortality after implantation of a bipolar endoprosthesis significantly decreased during the last 20 years^[6]. Strikingly, recruitment of most patients in recent studies comparing IF with arthroplasty in hip fracture patients date back a decade or even longer^[8-11,17,18,27,21-34]. In this regard, improved anaesthesia and modern cementing techniques might explain the difference of our results compared to earlier studies.

We believe that elderly and morbid patients may benefit from rapid restoration of continuing walking capacity with no pain and thus explaining the advantage of HA over IF in relation to 1-year mortality. In fact, our results demonstrated that the functional score of Merle'd Aubigne showed a considerable decrease in the IF group compared to a minor functional loss in the HA group at one year. HA was performed by attending surgeons and IF by residents in the vast majority of cases which might have influenced results. But with respect to our results and that of others^[17], no relationship between training of the surgeon and 1-year mortality exists.

Our study has several limitations. Lack of randomization resulted in a heterogeneous patient cohort and in a potentially significant bias. Despite correcting for multiple confounding variables in the Cox regression analysis, unknown or unmeasured confounders were not considered which is inherent to all observational studies. However, a difference in 1-year mortality was not found although patient selection penalized HA significantly in terms of patient age and comorbidities (ASA Score), some of the strongest predictors in mortality in femoral neck fracture patients^[17], among other parameters. Although our results indicate a higher 1-year mortality risk after IF, no causal conclusions can be drawn.

In summary, we conclude that elderly patients with a femoral neck fracture might benefit from cemented HA compared to IF with a SHS in terms of 1-year mortality. New RCTs considering the complete variety of femoral neck fracture patients, the delay in surgery and modern techniques in HA are needed to verify our results.

However, when deciding on the choice of implant individual patient characteristics and situations should be taken into account.

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